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(54) **Antenna**

Antenne

Antenne

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(56) References cited:
EP-A- 0 394 960
DE-U- 9 404 083
US-A- 5 437 091

- **PATENT ABSTRACTS OF JAPAN vol. 8, no. 213 (E-269), 28 September 1984 & JP-A-59 097204 (MATSUSHITA DENKI SANGYO K.K), 5 June 1984,**
- **FUJIMOTO ET AL: "Small Antennas", 1993, WILEY ,**

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EP 0 757 405 B1

Description

[0001] The present invention relates to low profile antennae, particularly but not exclusively to Inverted-F antennae.

[0002] Low profile antennae such as Inverted-L or F antennae are well known in the art, e.g. from JP 59 097209. An example of an Inverted-F antenna is shown in Figure 1 of the accompanying drawings. The antenna 100 comprises a feed section 102 coupled to a short circuited inductive stub 104 and a capacitative line 106. The inductive stub 104 is short circuited to a ground plane 108, above which the feed section 102 protrudes by a distance D. The ground plane 108 is open to allow access for the feed section 102 which is electrically insulated 110 from the ground plane 108. The respective lengths L_1, L_2, of the inductive stub 104 and the capacitative line 106 are determined to give a desired resonance frequency and input impedance Z_{in} to the antenna seen from the antenna feed point 112. The input impedance is dependant upon the position of the feed section 102 and hence lengths L_1 and L_2, and can be made wholly resistive. Typically, this is a 50 OHM impedance in order to match the output or input impedances respectively of commercially available power amplifiers and low noise amplifiers. Further details regarding inverted-L or F antennas may be found in "Small Antennas" ISBN 0 86380 048 3 pages 116-151.

[0003] Inverted-F antennae have found particular applications in the radio telephone art where their high gain and omni-directional radiation patterns are particularly suitable. They are also suitable for applications where good frequency selectivity is required. Additionally, sine the antennae are relatively small at typical radio telephone frequencies they can be incorporated within the housing of a radio telephone thereby not interfering with the overall aesthetic appeal of the radio telephone and giving it a more attractive appearance than radio telephones having external antennae. By placing the antenna inside the housing of a radio telephone, the antenna is also less likely to be damaged and therefore have a longer useful life. The inverted-F antenna lends itself to planar fabrication, and may suitably be fabricated on the printed circuit board typically used in a radio telephone to support the electronic circuitry, which lends itself to cheap manufacture.

[0004] However, despite their relatively small size the fact that radio telephones are becoming smaller and smaller, and more and more complex necessitating a greater amount of electronics within the housing, the space available for the inverted-F antenna is getting smaller and it is becoming more difficult to conveniently fit such antennae inside the housing. Placing such an antenna external to the housing is inconvenient since it must be conductively coupled through the housing to the components on the printed circuit board, and it removes the benefits normally associated with an internal antenna.

[0005] According to the present invention, there is provided a planar antenna disposed on a substrate, comprising a ground plane, a first conductive member disposed transverse to and electrically insulated from the ground plane, and a second conductive member electrically coupled to the first conductive member and having an open circuit end, wherein the second member is concave towards the ground plane.

[0006] This has an advantage in that the antenna is smaller than conventional inverted-L or F antennae and is therefore suitable as an internal antenna for apparatus which has little available space inside.

[0007] In a preferred embodiment of the invention the ground plane is correspondingly curved with respect to the second member. This has a surprising and unexpected advantage in that the radiation pattern is improved over that obtained with a flat ground plane and is similar to that from a conventional inverted-L or F antenna. Additionally, the amount of power radiated from the open circuit end is increased relative to that obtained with a flat ground plane antenna.

[0008] A curved antenna is disclosed in US 5 437 091.

[0009] Preferably, the separation between the second member and the ground plane is substantially constant, and suitably the separation between the second member and the ground plane is of the order of one tenth of the wavelength of the centre frequency of the antenna.

[0010] Advantageously, the second conductive member comprises a stub portion electrically coupled to ground and extending to a side of the first member in an opposing direction to the open circuit end. This results in the possibility of tuning out the respective reactances of the short circuited stub and open circuit end such that the antenna has a wholly resistive input impedance. When combined with the feature of a curved ground plane there is the advantage that the characteristic impedance of the antenna is independent of the open circuit length and hence it is easier to match the input impedance to the output impedance of conventional electronic devices, by locating the antenna feed at an appropriate point from the short circuited stub and open circuit end.

[0011] Typically the ground connection for the stub portion comprises a conductive element contacting the ground plane, and the first member, conductive element and open circuit end are substantially in line.

[0012] By arranging the first member and conductive element such that they are non-parallel the respective currents flowing in opposite directions in the first member and conductive element tend not to cancel in the far radiative field. Consequently, a greater radiated field is possible in a short circuit direction of the antenna than can be achieved with a conventional inverted-F antenna.

[0013] The antenna may be fabricated on a suitable substrate such as a printed circuit board, and the ground plane may be formed from a part of the radio frequency shielding for circuitry associated with an apparatus as-

sociated with the antenna.

[0014] Embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a conventional inverted-F antenna;

Figure 2 is a schematic diagram of a curved inverted-F antenna in accordance with a first embodiment of the invention;

Figure 3 is a schematic diagram of a curved inverted-F antenna with a curved ground plane in accordance with a second embodiment of the invention; and

Figure 4 is a schematic diagram of an embodiment of the invention showing a curved inverted-F antenna disposed on a printed circuit board and coupled to a ground conductor of the printed circuit board.

[0015] Figure 2 shows a schematic diagram of an antenna, named curved inverted-F antenna, in accordance with a first embodiment of the invention. When referring to Figure 2 like features to features in Figure 1 will be referred to by like reference numerals for Figure 1. The inductive stub 104 and capacitative line 106 of Figure 1 are now curved inductive stub 204 and curved capacitative line 206. The amount of space taken up by the curved inverted-F antenna along its longtitudinal axis is substantially less than that taken up by the conventional inverted-F antenna. Thus, the curved inverted-F antenna can fit into smaller spaces. As can be seen from Figure 2, the distance between the curved inductive stub 204 and curved capacitative line 206, and the ground plane varies, for example having distances D_1, D_2 and D_3. Since the curved inductive stub 204 is relatively short compared to the curved capacitative line 206, the effects of the curvature on the inductive stub 204 can be ignored. However, it is the Applicant's understanding that such effects cannot be ignored with regard to the curved capacitative line 206. The effect of the curvature is to give an effective characteristic impedance Z_o which is dependent upon the length L'_2 of the curved capacitative line 206. In terms of transmission line equations, this has the effect of providing an input impedance of the form,

$$Z_{I_n} = \frac{-jZ_o(L_{2'})}{\tan\beta L_{2'}}$$

where Z_{in} is the input impedance seen at the feed point to the antenna, Z_o (L'_2) is the length dependent effective characteristic impedance of the capacitative line, L'_2 is the length of the capacitative line and β is the phase of a signal propagating down the curved capacitative line 206. The dependence of the input impedance on two parameters which are functions of the length L'_2 of the curved capacitative line 206 makes the calculations for matching the antenna to a desired feed point impedance difficult, and further may have the effect of reducing the band-width of the antenna. Additionally, the open end 214 of the curved capacitative line 206 is closer to the ground plane 108 than the rest of the antenna and has the effect of closing off a radiating aperture of the antenna compared with the conventional inverted-F antenna. This has a detrimental effect on the radiation patterns of the antenna.

[0016] A preferred embodiment of the invention is shown schematically in Figure 3 where like features to those in Figures 1 and 2 are described using like reference numerals. In the preferred embodiment the ground plane 308 for the curved inverted-F antenna is correspondingly curved such that the distance D between the curved capacitative line 206 and the ground plane 308 remains substantially constant. This has the effect of removing the dual dependency of the input impedance on the length L'_2 of the curved capacitative line 206, and further maintaining the open end 314 of the curved capacitative line 206 at the greatest separation D from the ground plane 308. Thereby, giving good radiation from the open end 314 such that it is substantially similar to that obtainable from a conventional inverted-F antenna.

[0017] In the preferred embodiment of the invention the curved inverted-F antenna 416 is built on a printed circuit board 418 as shown in Figure 4. The antenna is designed to operate at a centre frequency of 1890MHz in a frequency band of 1880 to 1900MHz, and requires a bandwidth of at least one per cent of the centre frequency (1890MHz). The design parameters of the antenna 416 in accordance with the preferred embodiment of the invention are such that the width 316 of the curved inductive stub 204 and curved capacitative line 206 is 2mm. The thickness of the feed track 102 is 1mm and the distance D between the inside edge 322 of the antenna and the ground plane 308 is approximately one-tenth of the centre frequency wavelength, that is to say 8mm. The radius of curvature 320 of the outer edge of the antenna is 24.7mm, and the radius of curvature of the inner edge 322 of the antenna is 22.7mm. The radius of curvature of the ground plane is 13mm. The curved inverted-F antenna 416 is built on a printed circuit board made of any suitable material using conventional copper metalisation.

[0018] In the preferred embodiment, and as shown in Figure 4, the feed track 402 is not parallel to the short circuit 420 for the curved inductive stub 204, but instead each follow their respective radiuses. This has the effect that the current flowing in the feed track 402 and short circuit 420 are not parallel. Thus, even though the currents flow in opposite directions, unlike the conventional inverted-F antenna and the curved inverted-F antenna shown in Figures 2 and 3 these current contributions tend not to cancel in the far field region of the radiation

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patterns. Consequently, a curved inverted-F antenna in accordance with the embodiment shown in Figure 4 has greater radiated power in its short circuit direction than obtainable from a conventional inverted-F antennae. In practical applications of the present invention, it is necessary to provide testing contacts 422 on the printed circuit board 418 so that the performance of the antenna may be tested during manufacture. Such a testing contact is of course conductive and may act to perturb the performance of the antenna if it is too large. However, the Applicant has found that small perturbations such as that shown in Figure 4 as reference 422 do not unduly affect the performance of the antenna and can be tolerated. As can be seen in Figure 4, the curved inductive stub 204 is grounded to a ground conductor 424. This ground conductor 424 may form part of the ground conductor for the RF shielding of the radio telephone and consequently is a convenient ground connection for the curved inductive stub 204. Optionally, a radio frequency shield or cover may form the ground plane and ground connection for the curved inductive stub 204. This may be particularly useful should the curved inverted-F be fabricated on the interior of the housing of the radio telephone such that the conductive housing of the RF shield provides its ground plane.

[0019] The amount of curvature of the antenna, and correspondingly the ground plane, is in part determined by the radiation patterns the antenna is desired to generate. The Applicant is not aware of any limitations on the curvature due to impedance matching criteria.

Claims

1. A planar antenna (400) disposed on a substrate (418), comprising

   a ground plane,
   a first conductive member (402) disposed transverse to and electrically insulated from the ground plane, and
   a second conductive member (416) electrically coupled to the first conductive member and having an open circuit end, wherein the second member is concave towards the ground plane.

2. An antenna according to claim 1, wherein the ground plane is correspondingly curved with respect to the second member.

3. An antenna according to claim 1 or claim 2, wherein the separation between the second member and the ground plane is substantially constant.

4. An antenna according to claim 2 or claim 3, wherein the separation between the second member and the ground plane is of the order of one tenth of the wavelength of the centre frequency of the antenna.

5. An antenna according to any preceding claim, wherein the second conductive member comprises a stub portion (204) electrically coupled to ground and extending to a side of the first member (402) in an opposing direction to the open circuit end.

6. An antenna according to claim 5, wherein the stub portion is electrically coupled to ground via a conductive element (420) contacting the ground plane.

7. An antenna according to claim 6, wherein the first member (402) and conductive element (420) are non-parallel.

8. An antenna according to any preceding claim, and fabricated on a printed circuit board.

9. An antenna according to any preceding claim, wherein the ground plane forms a part of a radio frequency shielding for circuitry associated with the antenna.

Patentansprüche

1. Planarantenne (400), die auf einem Substrat (418) angeordnet ist und Folgendes aufweist:

   - eine Masseebene;
   - ein erstes leitendes Element (402), das transversal zur Masseebene angeordnet ist und elektrisch gegen diese isoliert ist; und
   - ein zweites elektrisches Element (416), das elektrisch mit dem ersten leitenden Element gekoppelt ist und ein offenes Schaltungsende aufweist, wobei das zweite Element zur Masseebene hin konkav ist.

2. Antenne nach Anspruch 1, bei der die Masseebene entsprechend wie das zweite Element gekrümmt ist.

3. Antenne nach Anspruch 1 oder Anspruch 2, bei der der Abstand zwischen dem zweiten Element und der Masseebene im Wesentlichen konstant ist.

4. Antenne nach Anspruch 2 oder Anspruch 3, bei der der Abstand zwischen dem zweiten Element und der Masseebene in der Größenordnung eines Zehntels der Wellenlänge der Mittenfrequenz der Antenne liegt.

5. Antenne nach einem der vorstehenden Ansprüche, bei der das zweite leitende Element einen elektrisch mit Masse verbundenen Blindleitungsabschnitt (204) aufweist, der sich in der Gegenrichtung zum offenen Schaltungsende zu einer Seite des ersten Elements (402) hin erstreckt.

6. Antenne nach Anspruch 5, bei der der Blindleitungsabschnitt über ein die Masseebene kontaktierendes leitendes Element (420) elektrisch mit Masse gekoppelt ist.

7. Antenne nach Anspruch 6, bei der das erste Element (402) und das leitende Element (420) nicht parallel sind.

8. Antenne nach einem der vorstehenden Ansprüche, die auf einer gedruckten Leiterplatte hergestellt ist.

9. Antenne nach einem der vorstehenden Ansprüche, bei der die Masseebene einen Teil einer Hochfrequenzabschirmung für eine Schaltung bildet, der die Antenne zugeordnet ist.

Revendications

1. Antenne planaire (400) disposée sur un substrat (418), comprenant

   un plan de masse,

   un premier élément conducteur (402) disposé transversalement au, et électriquement isolé du plan de masse, et

   un second élément conducteur (416) électriquement couplé au premier élément conducteur et comportant une extrémité de circuit ouverte, dans lequel le second élément est concave en direction du plan de masse.

2. Antenne selon la revendication 1, dans laquelle le plan de masse est incurvé de manière correspondante par rapport au second élément.

3. Antenne selon la revendication 1 ou 2, dans laquelle la séparation entre le second élément et le plan de masse est sensiblement constante.

4. Antenne selon la revendication 2 ou 3, dans laquelle la séparation entre le second élément et le plan de masse est de l'ordre d'un dixième de la longueur d'onde de la fréquence centrale de l'antenne.

5. Antenne selon l'une quelconque des revendications précédentes, dans laquelle le second élément conducteur comprend une partie de tronçon de ligne (204) électriquement couplée à la masse et s'étendant jusqu'à un côté du premier élément (402) dans une direction opposée à l'extrémité du circuit ouvert.

6. Antenne selon la revendication 5, dans laquelle la partie de tronçon de ligne est électriquement couplée à la masse via un élément conducteur (420) venant en contact du plan de masse.

7. Antenne selon la revendication 6, dans laquelle le premier élément (402) et l'élément conducteur (420) sont non parallèles.

8. Antenne selon l'une quelconque des revendications précédentes, fabriquée sur une carte de circuits imprimés.

9. Antenne selon l'une quelconque des revendications précédentes, dans laquelle le plan de masse forme une partie d'un blindage de radiofréquence destiné à un ensemble de circuits associés à l'antenne.

Fig.1.

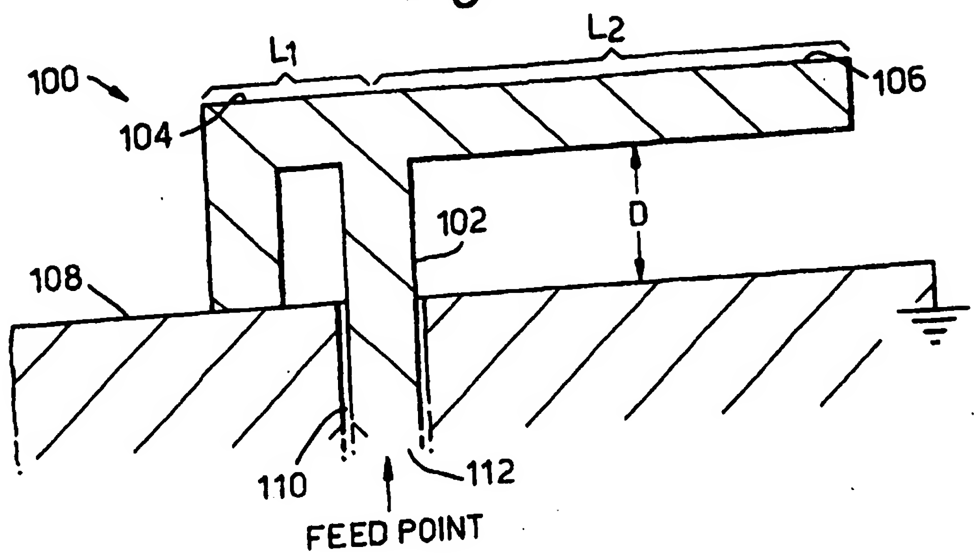

L1
L2
100
104
106
102
D
108
110
112
FEED POINT

Fig.2.

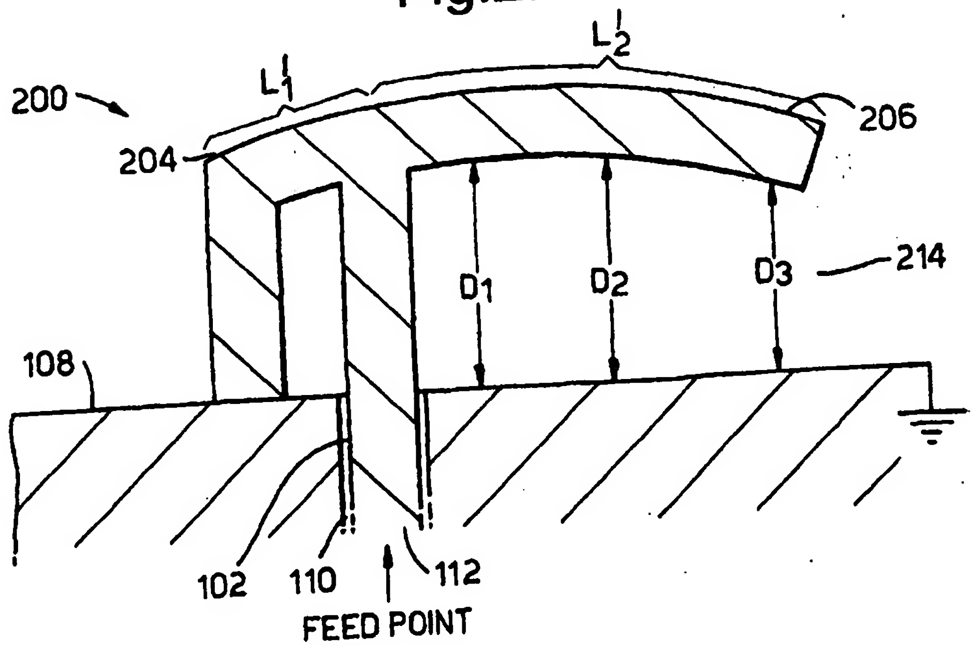

L'1
L'2
200
204
206
D1
D2
D3
214
108
102
110
112
FEED POINT

Fig.3.

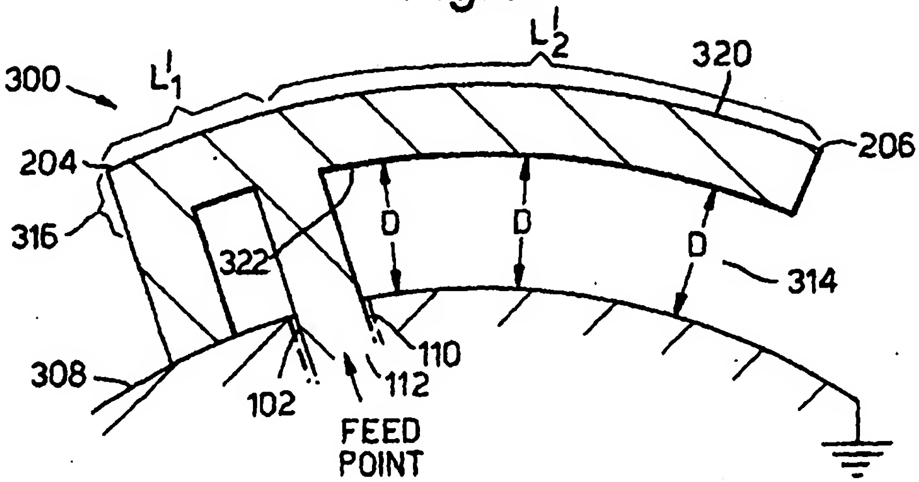
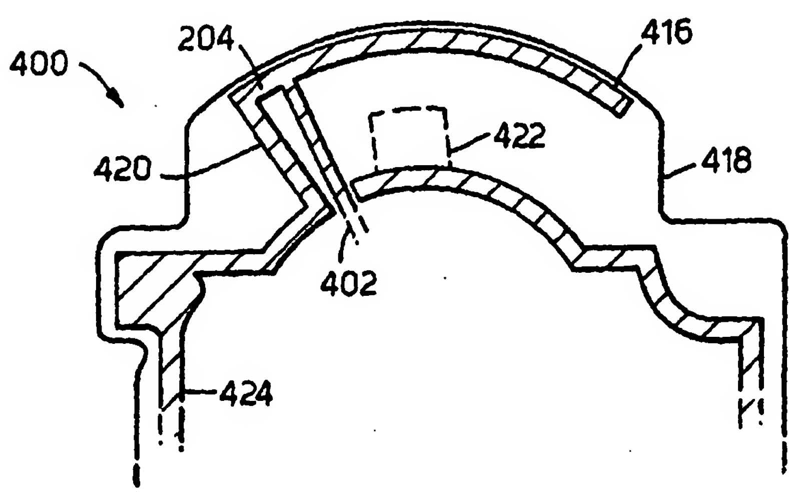

300
L'1
L'2
320
204
206
316
322
D
D
D
314
110
308
112
102
FEED
POINT

Fig.4.


400
204
416
422
420
418
402
424